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Optimal Finger Selection for Perfusion Index Measurement in Patients with Stable Chronic Obstructive Pulmonary Disease

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ABSTRACT

Introduction: Chronic obstructive pulmonary disease (COPD) may effect chronic hypoxemia due to ventilation–perfusion mismatch. The perfusion index (PI) based on pulse oximetry reflects peripheral perfusion and may vary by measurement site. This study evaluated differences in PI values among fingers to determine the most reliable site for PI measurement in patients with COPD.

Materials and Methods: This descriptive observational research with a cross-sectional design among patients with stable COPD attending the Pulmonology Clinic at Kolonel Abundjani General Hospital in August 2025. Subjects were recruited using consecutive sampling. Patient characteristics, including sex, age, smoking history, and Brinkman index, were obtained from medical records. Perfusion index measurements were taken from all fingers of both hands using a pulse oximeter and analyzed using descriptive statistics.

Results: A total of 22 patients with stable COPD were ivolvedncluded. Most participants were male (86.4%) and aged over 55 years (86.4%), with the majority having a history of smoking and a Brinkman index of 200–600 (45.5%). The highest mean PI value in the right hand was observed in the ring finger (4.89 ± 3.12), while in the left hand it was found in the index finger (5.59 ± 3.41). PI values tended to be higher in several fingers of the left hand. The coefficient of variation analysis showed considerable variability across all fingers, although the thumbs exhibited relatively lower variability. A significant difference was observed only in the middle finger between the right and left hands ($p = 0.012$). Age and smoking history were not significantly associated with PI values ($p > 0.05$).

Conclusion: PI measurements in patients with stable COPD varied across different fingers. The thumbs showed relatively more stable values and may represent more reliable sites for PI assessment.

KEYWORD: COPD, Perfusion Index, Finger Measurement, Oxygen Monitoring

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INTRODUCTION

A respiratory disorder, which is Chronic obstructive pulmonary disease (COPD), specified by progressive and persistent airflow limitation accompanied by structural damage to the lung tissue. This condition is primarily caused by chronic airway inflammation resulting from prolonged exposure to cigarette smoke or other harmful airborne particles and gases. The clinical manifestations of COPD along with dyspnea, chronic cough, and sputum production, with disease severity ranging from asymptomatic stages to severe respiratory failure.[1] In Indonesia, the current prevalence of COPD is estimated to range between 3.6% and 5.6%, with an increasing trend reported in recent years. Epidemiological data also indicate that COPD prevalence is higher among men than women and is more commonly observed in individuals living in rural areas, those aged ≥40 years, smokers, and workers exposed to hazardous dust or gases.[2]

Ventilatory impairment and abnormalities in gas exchange in COPD can lead to chronic hypoxemia due to ventilation–perfusion (V/Q) mismatch and reduced oxygen diffusion across the alveolar membrane. These pathophysiological changes make monitoring oxygenation status an essential component in the patients with COPD's clinical evaluation. International guidelines recommend the use of non-invasive techniques for continuous tests of oxygenation, particularly in patients with chronic lung diseases or respiratory disorders.[3] In addition, alterations in peripheral perfusion may influence the quality of signals obtained from oxygen monitoring devices, thereby making the evaluation of peripheral perfusion parameters relevant for the interpretation of oxygenation measurements.[4]

Pulse oximetry is a widely used non-invasive technique for continuously observing arterial oxygen saturation. Its operating principle is derived from the differential absorption of infrared and red light by deoxyhemoglobin and oxyhemoglobin, which allows the calculation of the proportion of oxygen-bound hemoglobin in arterial blood. The perfusion index (PI) defines the ratio between the static blood or non-pulsatile flow and pulsatile blood flow in peripheral tissues. This parameter primarily reflects the strength of peripheral perfusion at the monitoring site rather than the oxygen content of the blood.[5]

The perfusion index (PI) can be used to rapidly assess whether the sensor placement site is appropriate for pulse oximetry monitoring. The PI value typically ranges from 0.02%, indicating very weak pulsatile flow, to approximately 20%, which reflects strong pulsatile blood flow. Sites with higher PI values are generally considered more suitable for monitoring. Because PI is a relative parameter, its value may vary depending on physiological conditions, individual patient characteristics, and the monitoring site.[6] Measurements obtained from different anatomical locations may therefore yield different PI values. In particular, PI values may vary when measured on different fingers.[7] Consequently, the range of PI values considered normal may differ among patients.[6]

In patients with COPD, the PI represents a valuable parameter for assessing and monitoring peripheral perfusion. It may provide early warning signs of clinical deterioration, support decision-making regarding oxygen therapy, and contribute to improved overall patient management, particularly in critically ill or unstable conditions. In COPD patients, impaired oxygen delivery to tissues frequently occurs not only due to reduced arterial oxygen saturation (SpO_2), but also as a consequence of circulatory disturbances associated with chronic hypoxia, increased pulmonary pressure, and systemic inflammation.[8]

Despite the increasing clinical use of the PI in monitoring peripheral perfusion, the optimal finger location for PI measurement in patients with COPD persists unclear. Therefore, this research tended to determine differences in PI values among fingers and to determine the most reliable site for PI measurement in patients with COPD.

MATERIALS AND METHODS

This research used a descriptive observational design with a cross-sectional approach. The research was accomplished among patients diagnosed with stable COPD who attended the Pulmonology Clinic at Kolonel Abundjani General Hospital. The research population contained of all patients with stable COPD who visited the Pulmonology Clinic in August 2025. Subjects were recruited using a consecutive sampling method, in which all eligible patients who encountered the inclusion norm during the research period were involved until the required sample size was attained. Patients were excluded if they had another concomitant pulmonary diseases, such as asthma, pulmonary tuberculosis, or interstitial lung disease. Data on subject characteristics were obtained from medical records, including: Sex, Age, Smoking history, Brinkman Index, After confirmation of the COPD diagnosis, perfusion index (PI) measurements were performed on all fingers of both hands using a pulse oximeter. The measurements included: Right thumb, Right index finger, Right middle finger, Right ring finger, Right little finger, Left thumb, Left index finger, Left middle finger, Left ring finger and Left little finger. All perfusion index values were recorded for analysis. Data were analyzed using descriptive and inferential statistics. Categorical variables were showed as percentages and frequencies, while continuous variables were displayed as means ± standard deviations. Differences in perfusion index (PI) values between corresponding fingers of the right and left hands were determined through a paired t-test. The Pearson correlation test was employed to assess the relationship between subject characteristics (age and Brinkman index) and PI values. Statistical analyses were carried out using IBM SPSS Statistics version 25, with $p < 0.05$ appraised statistically significant.

RESULT

After screening the samples derived from the exclusion and inclusion criteria, a total of 22 patients diagnosed with COPD and attending follow-up visits at the Pulmonology Clinic of Colonel Abundjani Regional General Hospital during August 2025 were included in the study.

Table 1. Characteristics of Patients with Stable of Chronic Obstructive Pulmonary Disease

Characteristics	Frequency	Percentage (%)
Gender		
• Male	19	86,4
• Female	3	13,6
Age		
• < 40 Years	0	0
• 40-55 Years	3	13,6
• >55 Years	19	86,4
Brinkman Index		
• <200	6	27,3
• 200-599	10	45,5
• ≥600	6	27,3
Perfusion Index		
Right-hand		
• Thumb	3,74 ± 2,12*	
• Index finger	3,45 (0,5-12,9)#	
• Middle finger	4,00 (0,2-9,6)#	
• Ring finger	4,89 ± 3,12*	
• Little finger	3,90 (0,3-14,3)#	
Left Hand		
• Thumb	4,33 ± 2,50*	
• Index finger	5,59 ± 3,41*	
• Middle finger	6,25 (1,1-18,3)#	
• Ring finger	4,35 (0,3-18,7)#	
• Little finger	3,85 (0,3-15,9)#	

*Mean

#Median

As displayed in Table 1, the most of participants were male (19 patients, 86.4%), while 3 patients (13.6%) were female. The age distribution indicated that most patients were older than 55 years (19 patients, 86.4%). Most subjects also had a history of smoking, with the highest proportion having a Brinkman index of 200–600 (45.5%), indicating substantial exposure to tobacco-related risk factors within this population. Regarding perfusion index (PI) measurements, the highest mean value among the fingers of the right hand was observed in the ring finger (4.89 ± 3.12), whereas the left hand showed the highest mean PI value in the index finger (5.59 ± 3.41). Overall, PI values measured on several fingers of the left hand tended to be higher than those measured on the right hand.

Table 2 Coefficient of Variation of the Perfusion Index

Finger	Mean	SD	Coefficient of Variation (%)
Right-hand			
• Thumb	3,74	2,11	56
• Index finger	3,45	3,95	114
• Middle finger	4,00	3,26	81
• Ring finger	4,89	3,12	63
• Little finger	3,90	4,04	103
Left-hand			
• Thumb	4,33	2,49	58
• Index finger	5,59	3,41	61
• Middle finger	6,25	4,35	69
• Ring finger	4,35	4,85	111
• Little finger	3,85	4,63	120

Table 2 presents the results of the coefficient of variation analysis of PI values across the fingers of the right and left hands. The analysis demonstrated considerable variability in PI values across all fingers. The coefficient of variation ranged from 56% to 114% in the right hand and from 58% to 120% in the left hand. The lowest variation in the right hand was observed in the thumb (56%), while in the left hand it was found in the thumb (58%). In contrast, the highest variation was observed in the right index finger (114%) and the left little finger (120%). The highest mean perfusion index value was recorded in the left middle finger, with a mean value of 6.25. The relatively lower variation observed in both the right and left thumbs suggests that PI measurements at these sites tend to be more stable compared with those obtained from other fingers.

Table 3 Comparison of Perfusion Index Between the Fingers of the Right and Left Hands

Finger	Right (Mean ± SD)	Left (Mean ± SD)	p Value
• Thumb	3,74 ± 2,11	4,33 ± 2,49	0,156
• Index finger	3,45 ± 3,95	5,59 ± 3,41	0,567
• Middle finger	4,00 ± 3,26	6,25 ± 4,35	0,012*
• Ring finger	4,89 ± 3,12	4,35 ± 4,85	0,414
• Little finger	3,90 ± 4,04	3,85 ± 4,63	0,787

* *Paired t-test* p<0,05

Table 3 displays the oucomes of the PI comparison values between the fingers of the left and right hands using a paired *t*-test. The analysis presented no significant difference statistically in PI values between the left and right thumbs ($p = 0.156$). Similarly, no significant difference was discovered between the right and left index fingers ($p = 0.567$). Comparable results were also found for the left and right ring fingers ($p = 0.414$) and the right and left little fingers ($p = 0.787$), showing no statistically significant differences. In contrast, a significant difference was discovered in the middle finger between the right and left hands. The statistical test yielded a t value of -2.752 with a sig. level of $p = 0.012$, presenting that the perfusion index value in the left middle finger was higher than that in the right middle finger.

Table 4 Correlation Between Subject Characteristics and Perfusion Index

	Right-hand					Left-hand				
	T	I	M	R	L	T	I	M	R	L
Age	r=0,38 p=0,09	r=0,19 p=0,41	r=-0,002 p=0,99	r=-0,08 p=0,72	r=0,08 p=0,72	r=-0,11 p=0,64	r=0,04 p=0,87	r=-0,005 p=0,98	r=0,05 p=0,81	r=0,22 p=0,33
Brinkman Index	r=-0,10 p=0,65	r=-0,18 p=0,43	r=-0,08 p=0,72	r=-0,12 p=0,59	r=-0,02 p=0,94	r=-0,18 p=0,42	r=-0,03 p=0,89	r=-0,29 p=0,18	r=-0,26 p=0,25	r=0,03 p=0,89

T:Thumb, I:Index, M:Midle, R:Ring, L:Little

Table 4 presents the results of the analysis examining the association between the characteristics of the study subjects and perfusion index (PI) values. The Pearson correlation test demonstrated no significant association between age and PI values across all fingers of both the left and right hands ($p > 0.05$). This finding indicates that increasing age was not significantly related to changes in perfusion index values among patients with stable COPD. Similarly, no significant relationship was discovered between the Brinkman index and PI values across all fingers ($p > 0.05$). The correlation coefficients obtained for each finger indicated weak to very weak associations. These findings suggest that smoking history, as assessed by the Brinkman index, was not significantly associated with perfusion index values. Overall, age and smoking history were not significantly related to perfusion index values in patients with stable COPD.

DISCUSSION

This research showed that most of participants were male (86.4%) and older than 55 years (86.4%), which is consistent with the epidemiological pattern of COPD, where the prevalence is higher among older men due to prolonged term exposure to cigarette smoking. Yunus et al. (2019) reported that most COPD patients treated at Persahabatan Hospital were men aged ≥60 years, reflecting the cumulative exposure to respiratory risk factors.[8] A cohort study conducted in Japan also demonstrated an increasing incidence of COPD among men with advancing age, particularly among smokers.[9] Most subjects in the present study had a Brinkman index of 200–600 (45.5%), indicating moderate to heavy tobacco exposure. This discovery is consistent with the research by Mulyawan and Setiawan (2024), which reported a significant association between the Brinkman index and decreased lung function.[10]

However, a community-based study in Indonesia suggested that the Brinkman index may not always serve as an independent predictor of COPD after multivariate analysis.[11] In addition, the variation in perfusion index values across different fingers observed in this research is consistent with the findings of Swain et al. (2022), who reported significant differences in perfusion index measurements among fingers, possibly influenced by variations in peripheral vascular supply.[7]

The data in this study also demonstrated considerable variability in perfusion index (PI) values across all fingers, with coefficients of variation ranging from 56% to 114% in the right hand and 58% to 120% in the left hand. This variability suggests that PI values may be influenced by the measurement site. These discoveries are consistent with those of Swain et al. (2022), who reported significant differences in PI values between fingers with low to moderate agreement.[7] Lima et al. (2005) also noted that PI is influenced by peripheral perfusion dynamics and hemodynamic conditions, which may lead to variability between individuals and measurement sites.[12] However, Aboy et al. (2011) reported that peripheral perfusion values in healthy individuals tend to remain relatively stable under controlled environmental conditions. The lower variation observed in the thumb in the present study may be related to the vascular supply from the radial artery, whereas the higher variation observed in the index and little fingers may reflect greater sensitivity of peripheral perfusion to local blood flow changes.[13]

The findings of this study indicate that most fingers did not show significant differences in PI values between the left and right hands, except for the middle finger, which demonstrated a higher value in the left hand ($p = 0.012$). This result is consistent with the reseacrh from Swain et al. (2022), who reported that although variations in PI values may occur among different fingers, differences between the two hands are generally not statistically significant.[7] Lima and Bakker (2005) also suggested that PI is primarily influenced by peripheral perfusion and local vascular tone; therefore, differences between body sides are typically minimal under stable hemodynamic conditions.[12] However, Shelley (2007) reported that factors such as hand dominance, peripheral temperature, and microcirculatory conditions may contribute to variations in perfusion among fingers and between hands.[14] The difference observed in the middle finger in this study may be related to its dual vascular supply from the radial and ulnar arteries, which may influence local perfusion variability.[15]

Further analysis in this study demonstrated that age and the Brinkman index were not significantly associated with PI values across all fingers ($p > 0.05$). These discoveries recommend that in patients with stable COPD, demographic factors and smoking history may not be directly related to peripheral perfusion changes. This result is consistent with the findings of Lima and Bakker (2002), who reported that PI primarily reflects acute peripheral perfusion conditions influenced by hemodynamic factors such as vascular tone and peripheral temperature rather than demographic characteristics.[12] Hales et al. (2013) also reported no strong correlation between age and PI values under physiologically stable conditions. Nevertheless, Middlekauff et al. (2014) suggested that chronic exposure to cigarette smoke may lead to microvascular dysfunction, which could potentially reduce peripheral blood flow. The discrepancy between these discoveries may be related to differences in research populations, clinical conditions, and methods used for perfusion assessment.[16]

CONCLUSION

Perfusion index (PI) assesstments in patients with stable COPD demonstrated considerable variability across different fingers of both hands. However, no significant differences were discoveried between the right and left hands except in the middle finger and neither age nor smoking history indicated a significant association with PI values, while the thumbs exhibited relatively more stable measurements.

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